



## High Output Maximum Efficiency Protoype Diode Pumped Laser for Space Applications

Presented by

Dr. D. Barry Coyle: Code 600, NASA/GSFC

With

Dr. Richard Kay: American University

Paul Stysley: American University

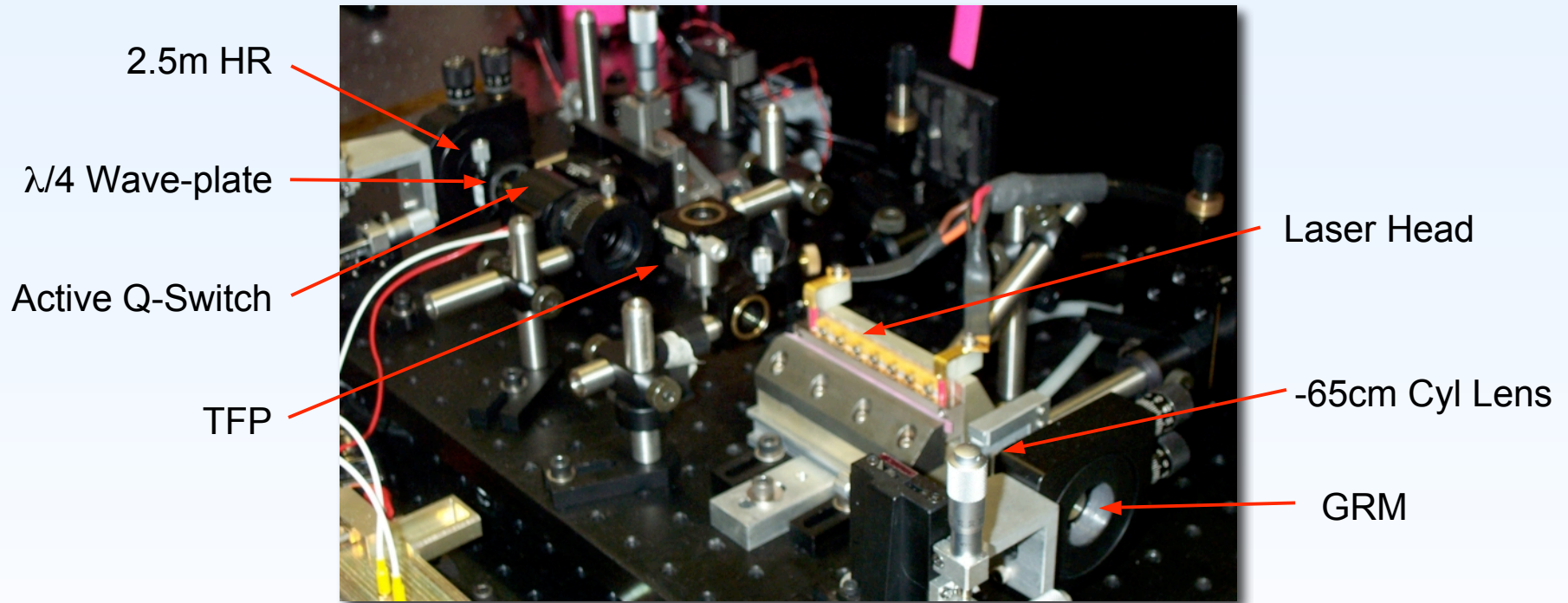
Dr. Demetrios Poullos: American University



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# High Output Maximum Efficiency Resonator (HOMER)



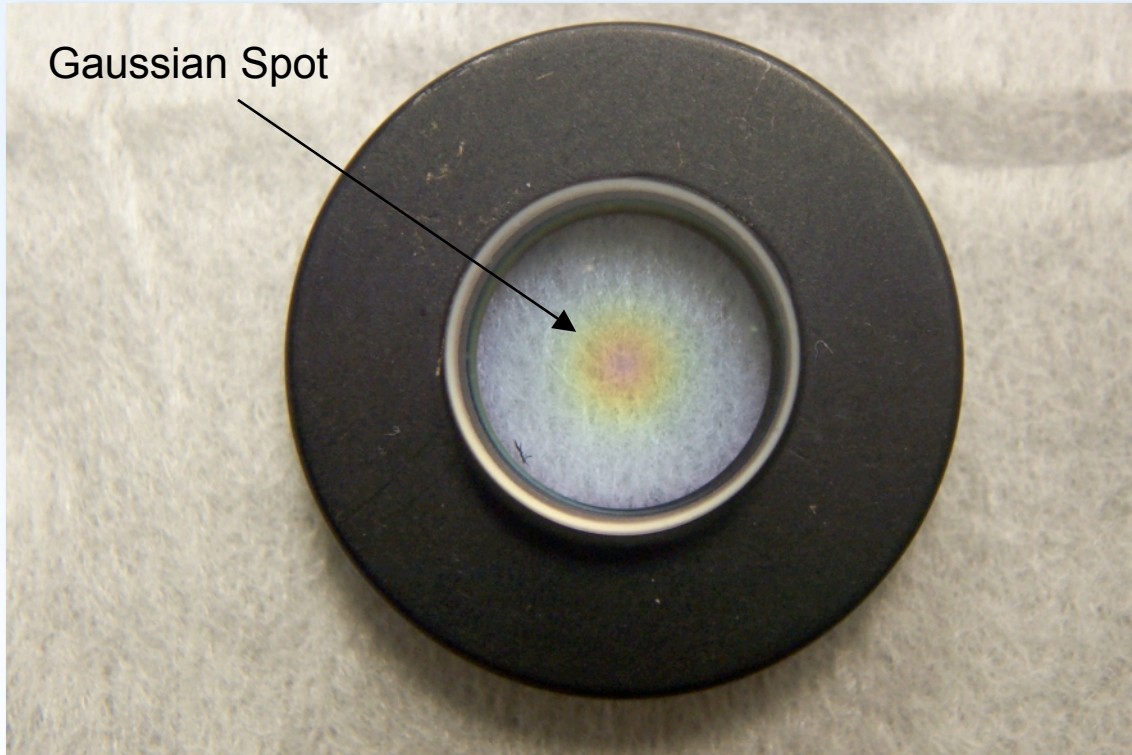
- Begun as High Efficiency Laser Transmitter (HELT)
- Used as bread board test bed for solving VCL damage issues
- 41cm cavity length
- Positive Branch Unstable Resonator (PBUR) cavity
- 20mJ @ 100Hz or 17mJ @ 240Hz
- Design focuses on reliability, efficiency, and lifetime



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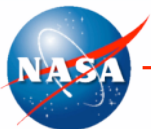
# Graded Reflectivity Mirror



- Gaussian profile
- $R_{eff} = 33\%$
- Radius of Curvature =  $-237\text{cm}$
- Used to achieve  $TM_{00}$  gaussian beam
- Combined with  $2.5\text{m}$  HR, gives large beam in relatively small cavity length

**Note:**

- Unstable resonator does not “act” like a stable cavity in the near field, but performs well in the far field and has greater efficiency.
- Unstable resonator has good mechanical stability, similar to a  $g_1g_2 = 0.6 - 0.7$  on a stability diagram.

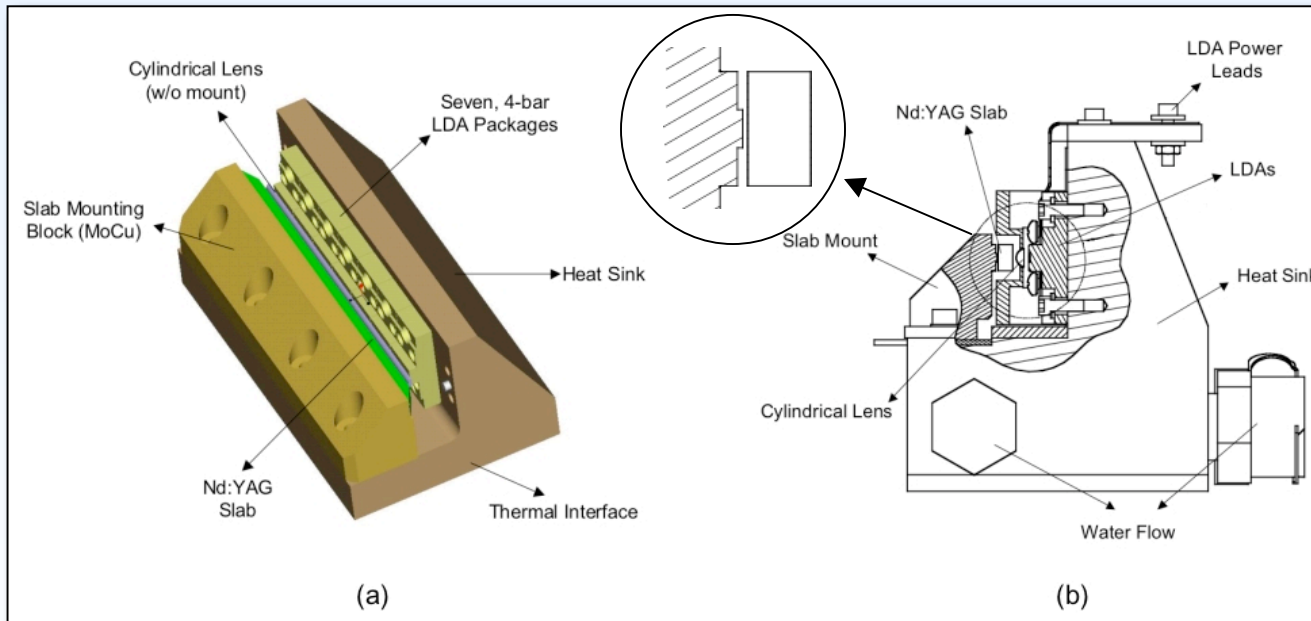


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# HOMER Laser Head/Slab

## Laser Head



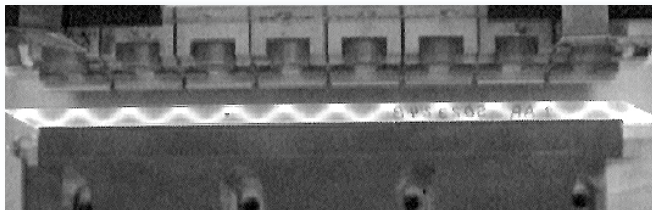
### Laser Head:

- Water cooled heat sink
- MoCu step mount
- Slab and pumpkins location easily adaptable

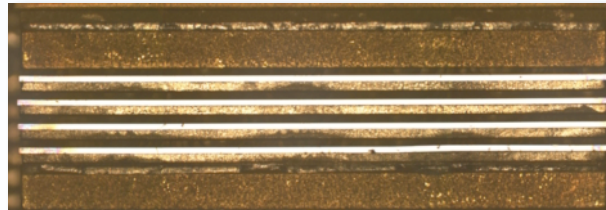
### Laser Slab:

- 1.1% Doped Nd:YAG
- ~90mm center x 5mm wide x 2.65mm thick
- Even bounce (22) less susceptible to pointing error
- 26.5° tip angle for maximum gain overlap

## Nd:YAG Slab

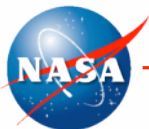


## SDL Diode



### Diodes:

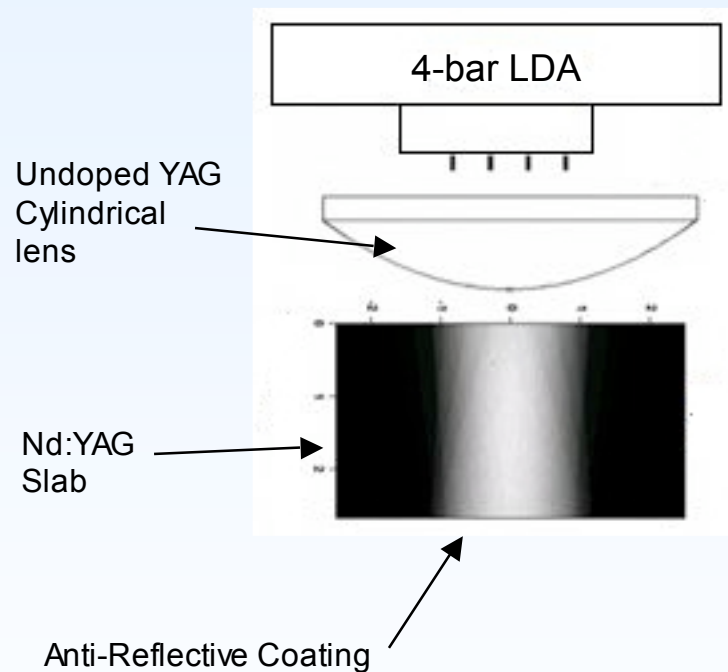
- 7 x 4 bar Spectra Diode Labs (SDL) diode array
- 60W per bar at 70A
- De-rated at ~20% to improve lifetime



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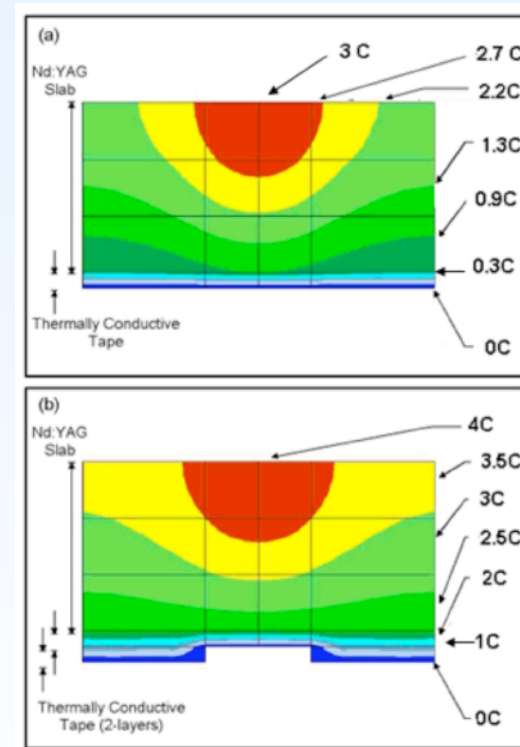


# HOMER Slab Pumping & Lensing



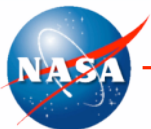
## Pumping Scheme:

- Cylindrical pump lens collimates pump beam in the fast axis
- Location of pump lens key for maximizing inversion density and coating damage consideration



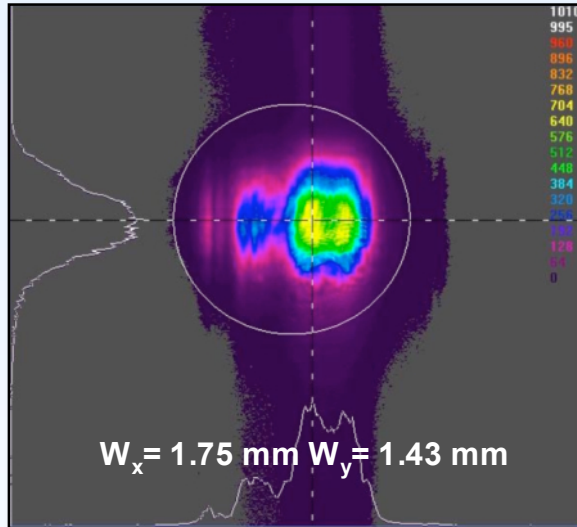
## Thermal Lensing:

- (a) Thermal lensing intense due to pump beam (b) Lensing is reduced with combination of 2-layers of thermally conductive tape and step mount
- Beam is rounded with the use of a intra-cavity cylindrical lens

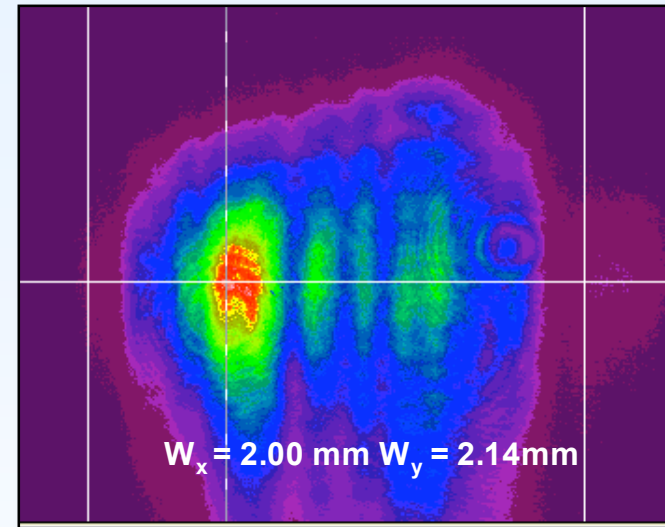


# HOMER Lifetest Parameters - Typical Output

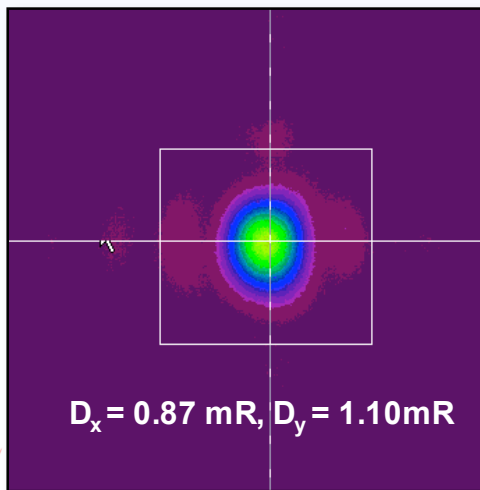
Intracavity Beam at HR



GRM Near Field



Far Field Image

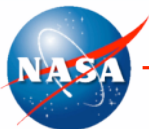


## Typical Laser Settings:

- Diode Pulse = 88 - 105us
- F = 242Hz
- Q-Switch Pulse ~ 9-10ns

## Typical Output:

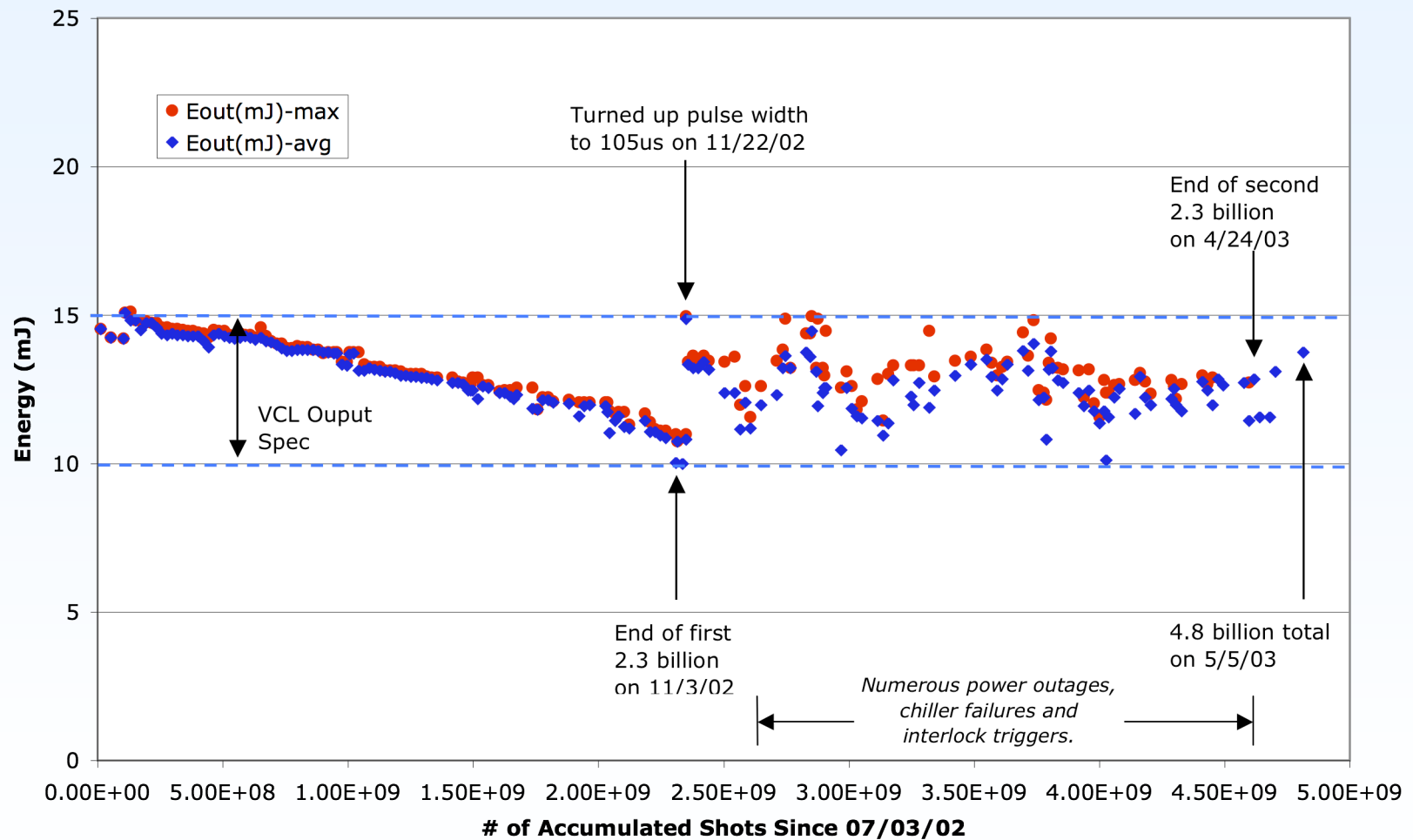
- E = 15-10 mJ
- M<sup>2</sup><sub>x</sub> ~ 1.29 M<sup>2</sup><sub>y</sub> ~ 1.74
- Efficiency as high as 12.5%
- Fluence < 3 J/cm<sup>2</sup>
- 4.8 billion total shots



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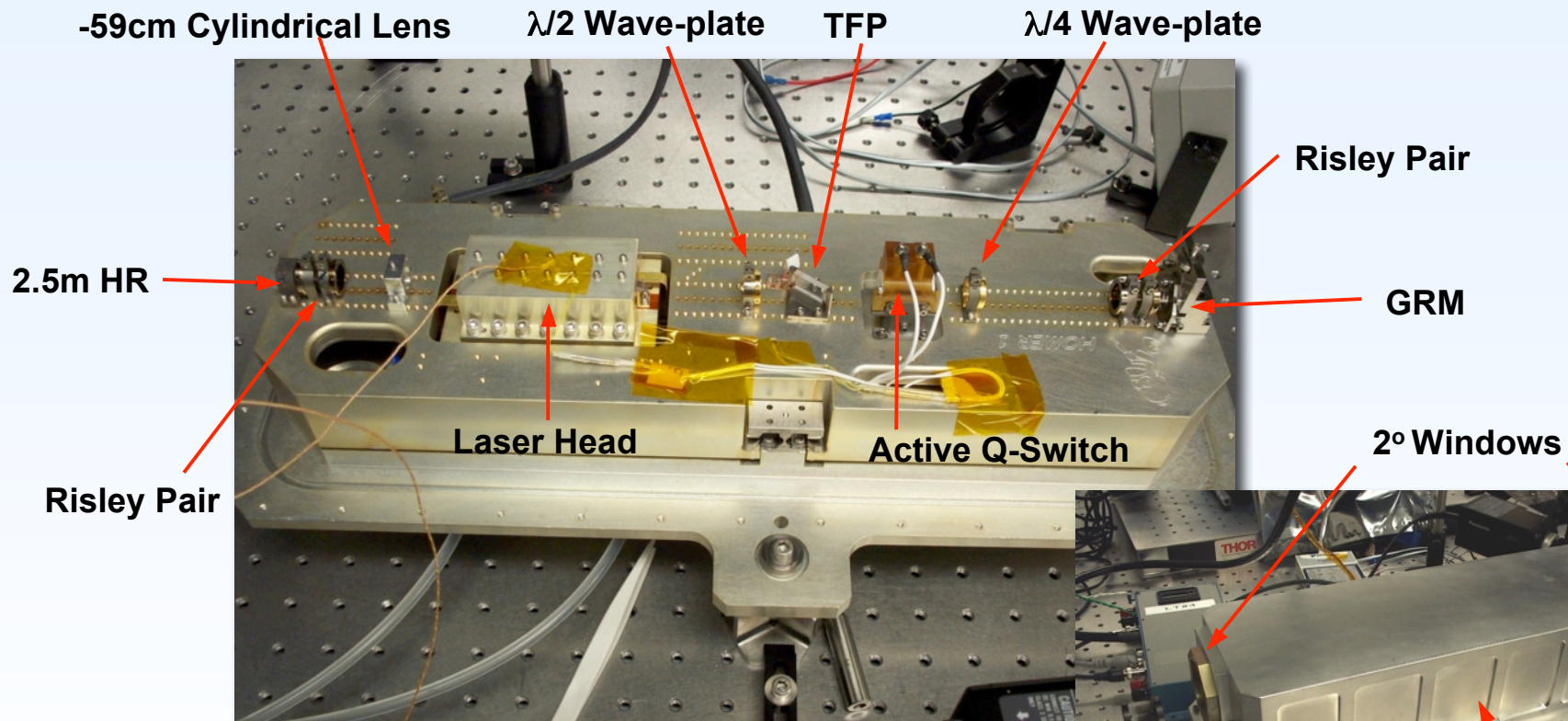
# HOMER 4.8 x 10<sup>9</sup> Shot Lifetime Study Results



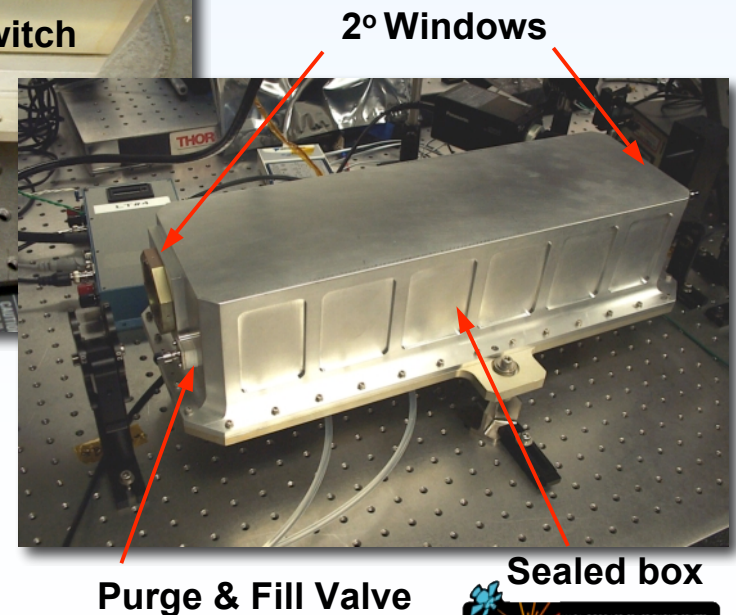
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# HOMER-ETU



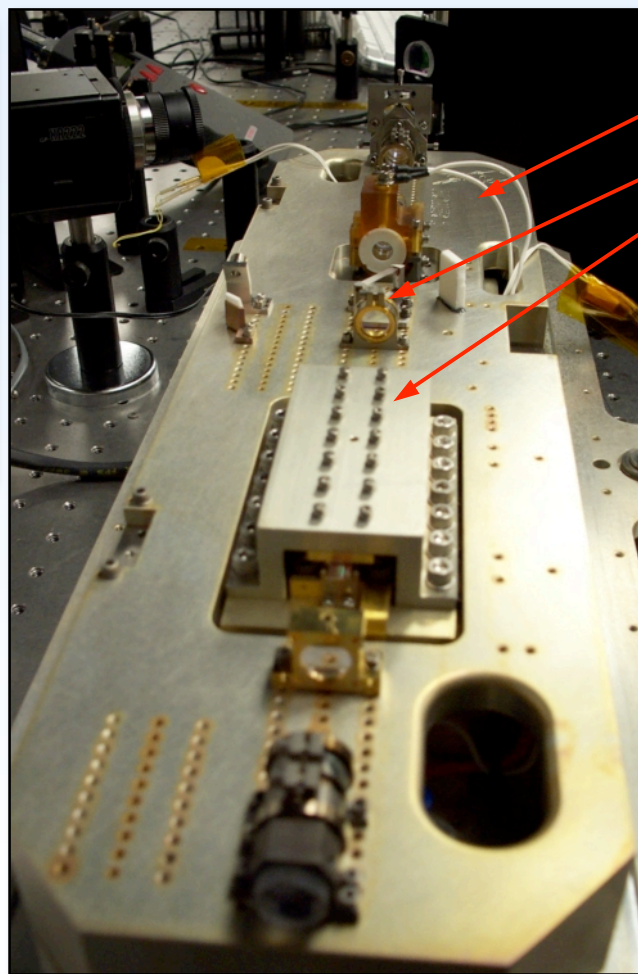
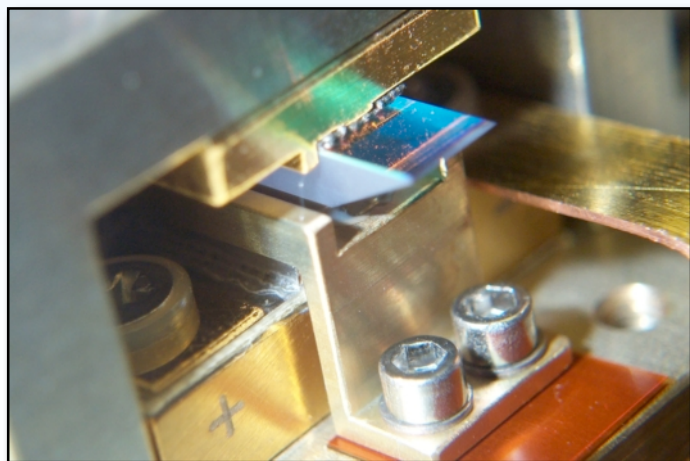
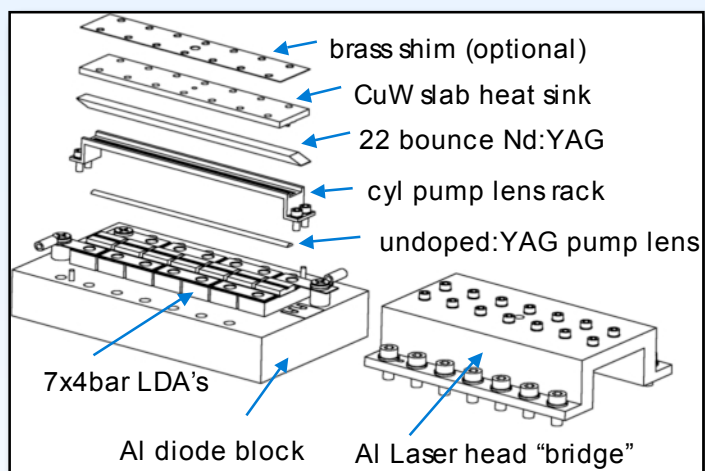
- ETU version of HOMER for evacuated testing
- 1st copy delivered 48" telescope at GSFC's GGAO for the MLA flyby calibration test (June 2005)
- Also obtaining long term operation data
- Eventual delivery to Code 554 as upgrade to "Marge" (Breadboard 20mJ oscillator)



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# Improvements: Mechanical



Flight like laser bench  
Flight optics mounts  
Laser head

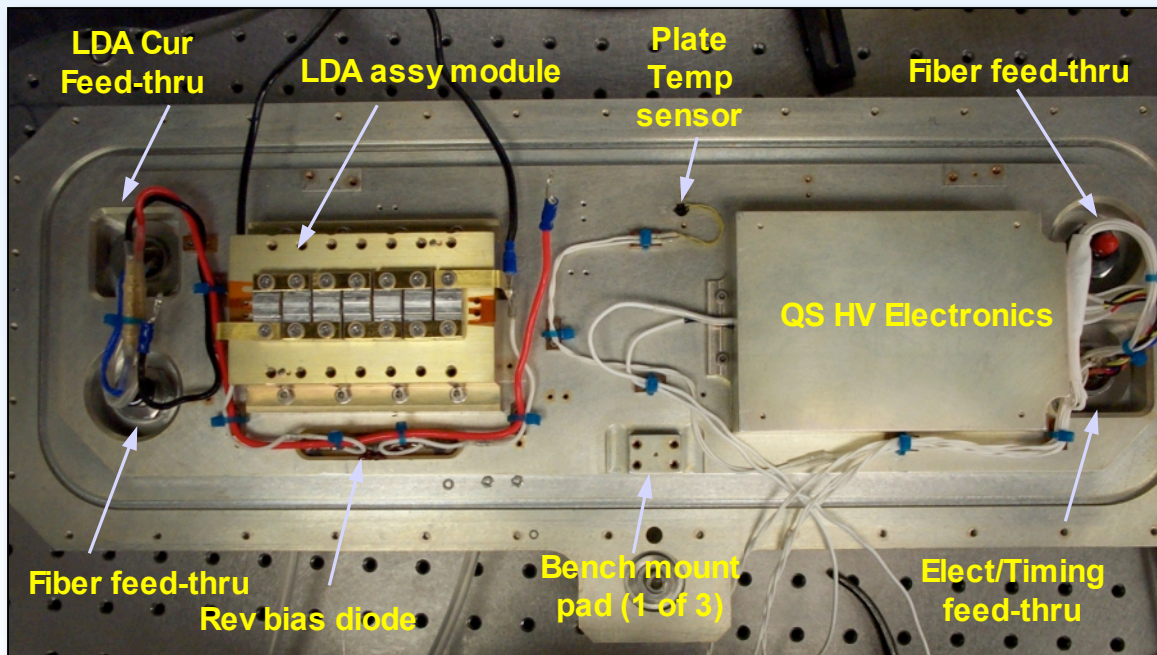
- Thermally isolated from bench
- Greatly reduced slab warping
- Pinned and modular components for repeated inspections.
- Elkonite slab heat sink matches Nd:YAG's CTE.
- Modular Aluminum diode pedestal conducts heat to base.



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# Improvements: New-ish LDA Products



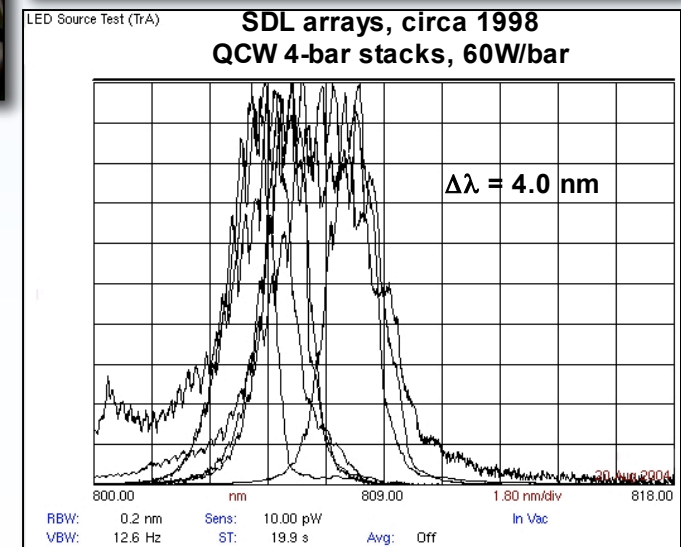
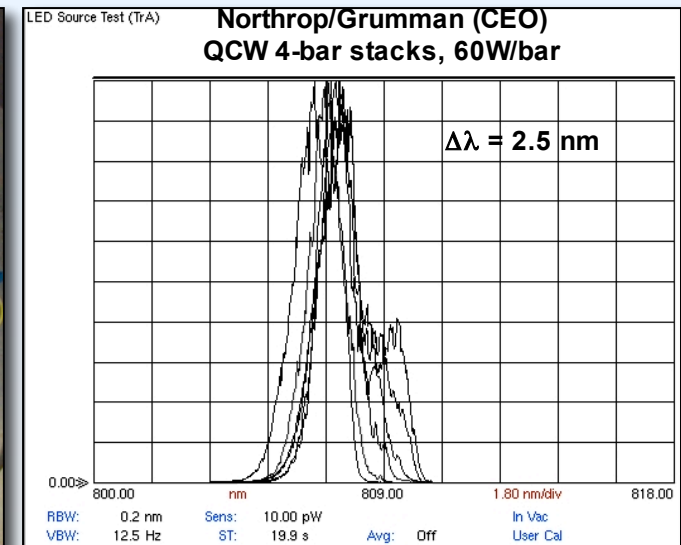
- 7 X 4-bar pump assy
- Back-cooled "G" packages
- 60W/bar peak @ 70A
- New 4-bar stacks are narrower in  $\lambda$  which means:

Good {

- higher effective  $\sigma_{\text{abs}}$
- Increased pump efficiency in laser
- Allows for running diodes derated ~30%

Not Good {

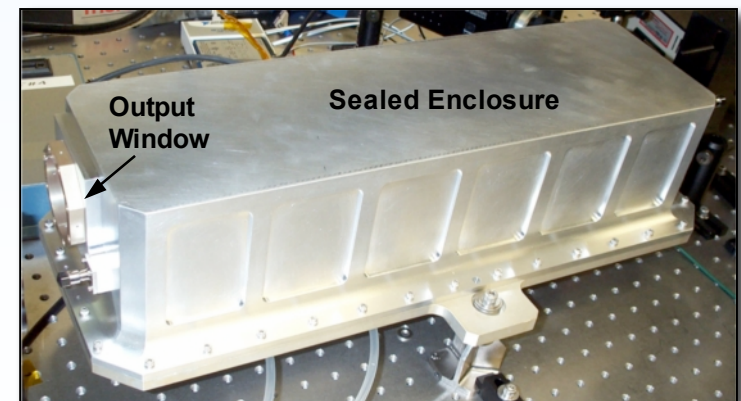
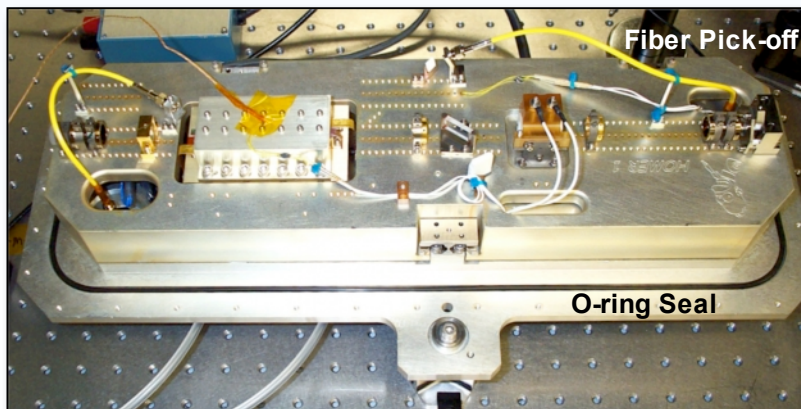
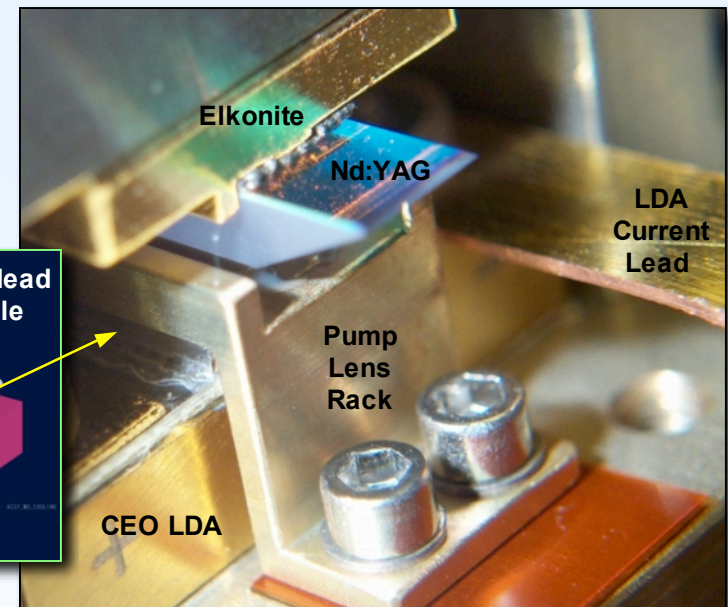
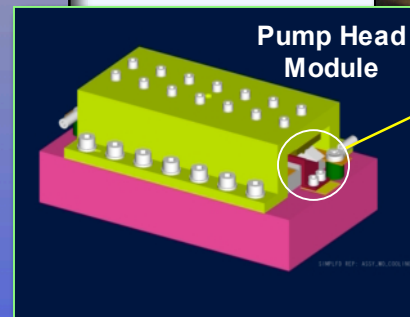
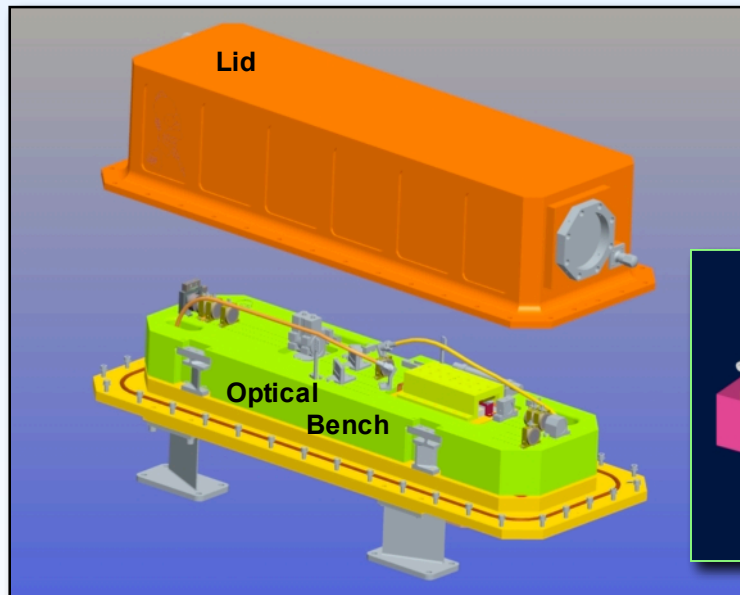
- *hotter slab pump face/stronger thermal lens*
- *narrower temp band*



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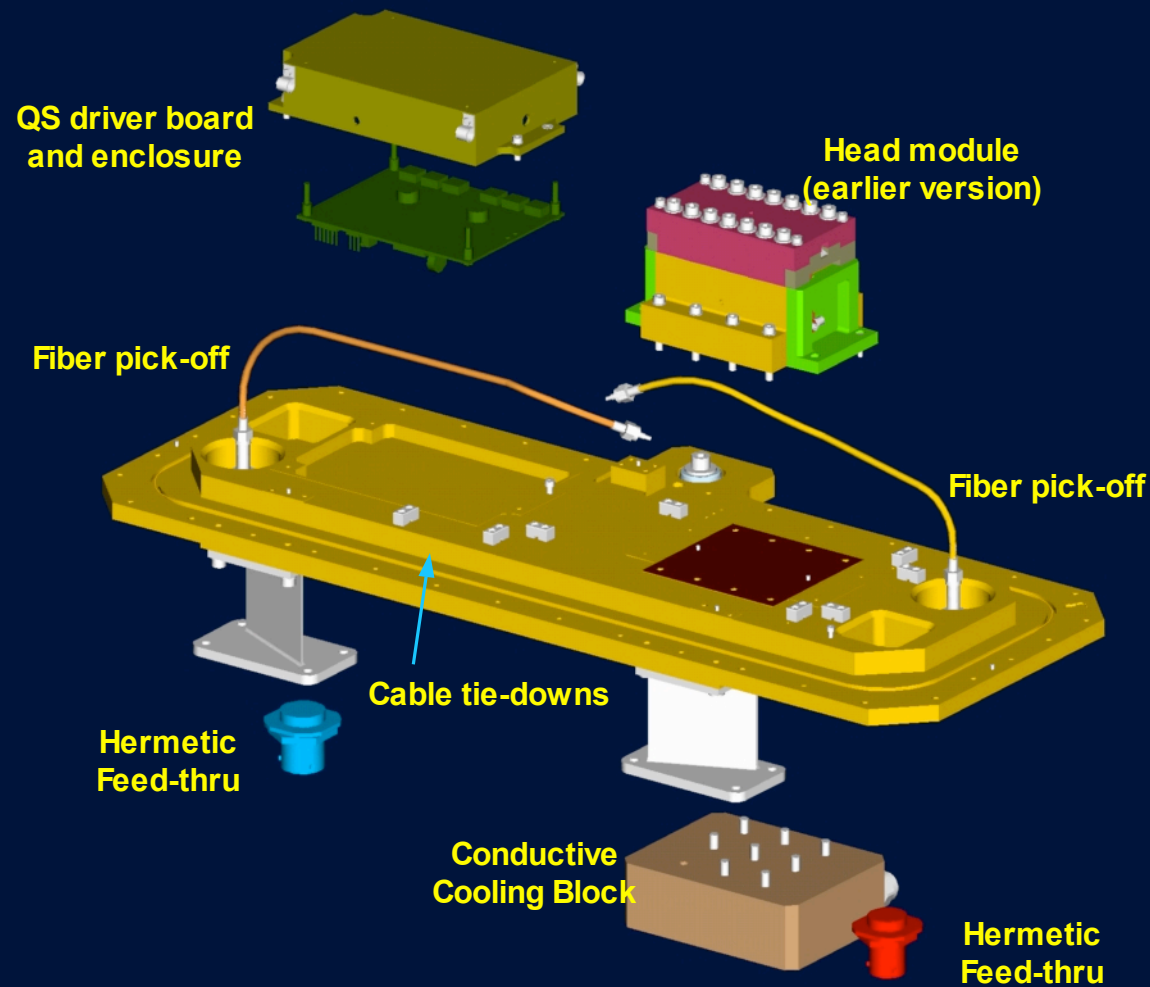
# HOMER Hardware



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# HOMER Hardware: Base Plate

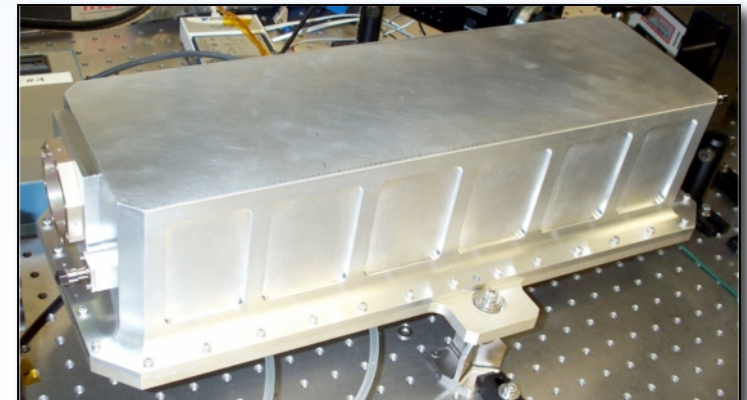
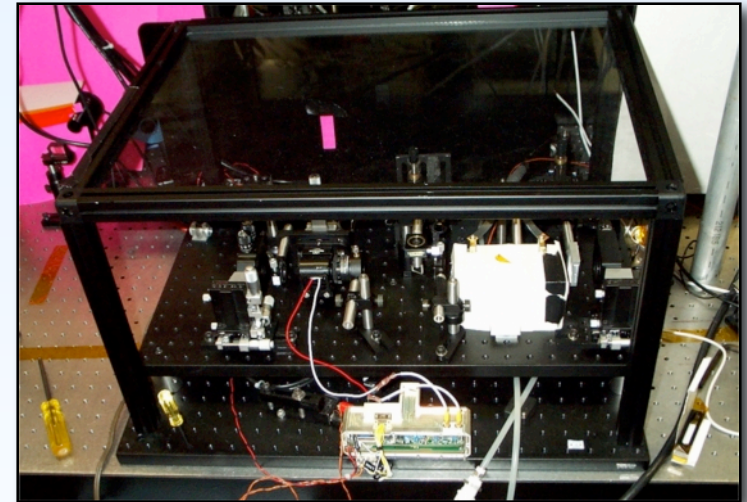


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# HELT/HOMER Comparison

Parameter	2003 HELT 4.8 x 10 <sup>9</sup> shot run	2005 HOMER BOL Performance
Pulse E @ 1064 nm	15 - 11 mJ	16 mJ
Rep Rate	242 Hz	242 Hz
Diode Pulse Width	89 - 95 us	80 us (100 us)
Gain Material	1.1% Nd:YAG	1.1% Nd:YAG
# Zig Zag Bounces	24	22
Slab Dimensions	2.64 x 100 x 5 mm	2.67 x 90 x 5 mm
LDA Supplier	SDL	NG/CEO
Diode Current	59 A	57 A (48 A)
Beam Divergence	0.9 x 1.1 mR	1.0 x 0.9 mR
LDA Current Derating	17 %	26 % (36 %)
LDA Linewidth $\Delta\lambda$	4.5 nm	2.5 nm
Test Setup	Open cavity in lab	Sealed box w/ dry air
Optical Effic.	12.5 - 10.4 %	16.1 % (14.9 %)

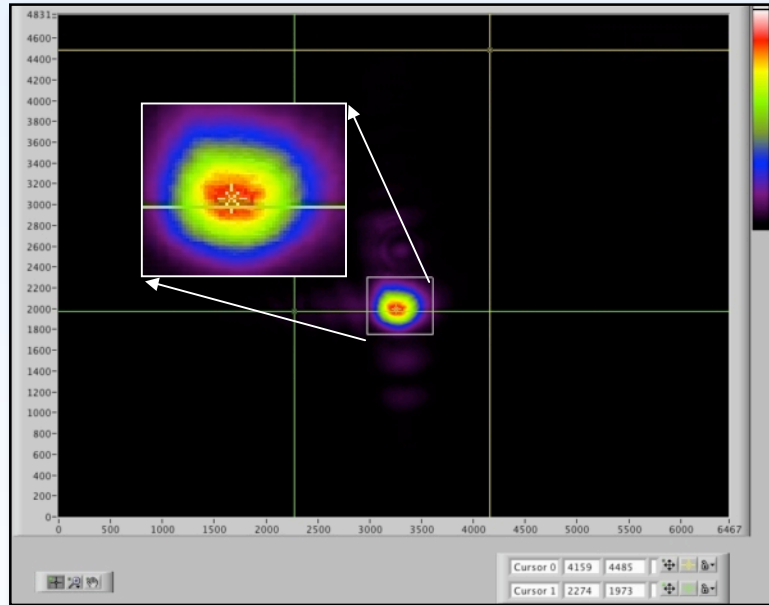


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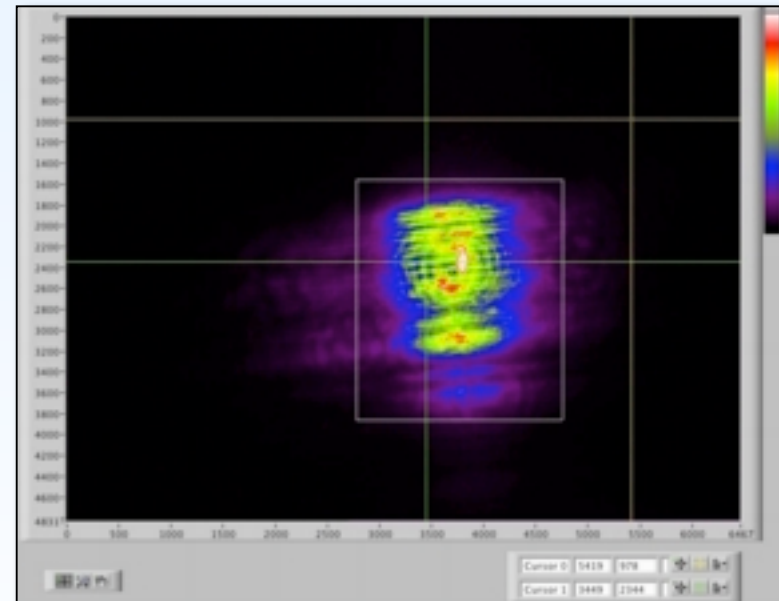


# Typical HOMER-ETU Output

Far Field Image:  
 $D_x/D_y = 1.1/1.0$  urad



HR mirror image:  
 $W_x/W_y = 2.2/1.7$  mm



## Typical Laser Settings:

- Diode Pulse = 85us-88us
- I = 50 A (~30% derated)
- F = 240 Hz
- Q-Switch Pulse ~ 9-10ns

## Typical Output:

- E = 17 mJ
- $M^2_x \sim 1.48$   $M^2_y \sim 1.53$
- Efficiency as high as 16.5%
- Fluence < 2.5 J/cm<sup>2</sup>
- 1.8 billion total shots



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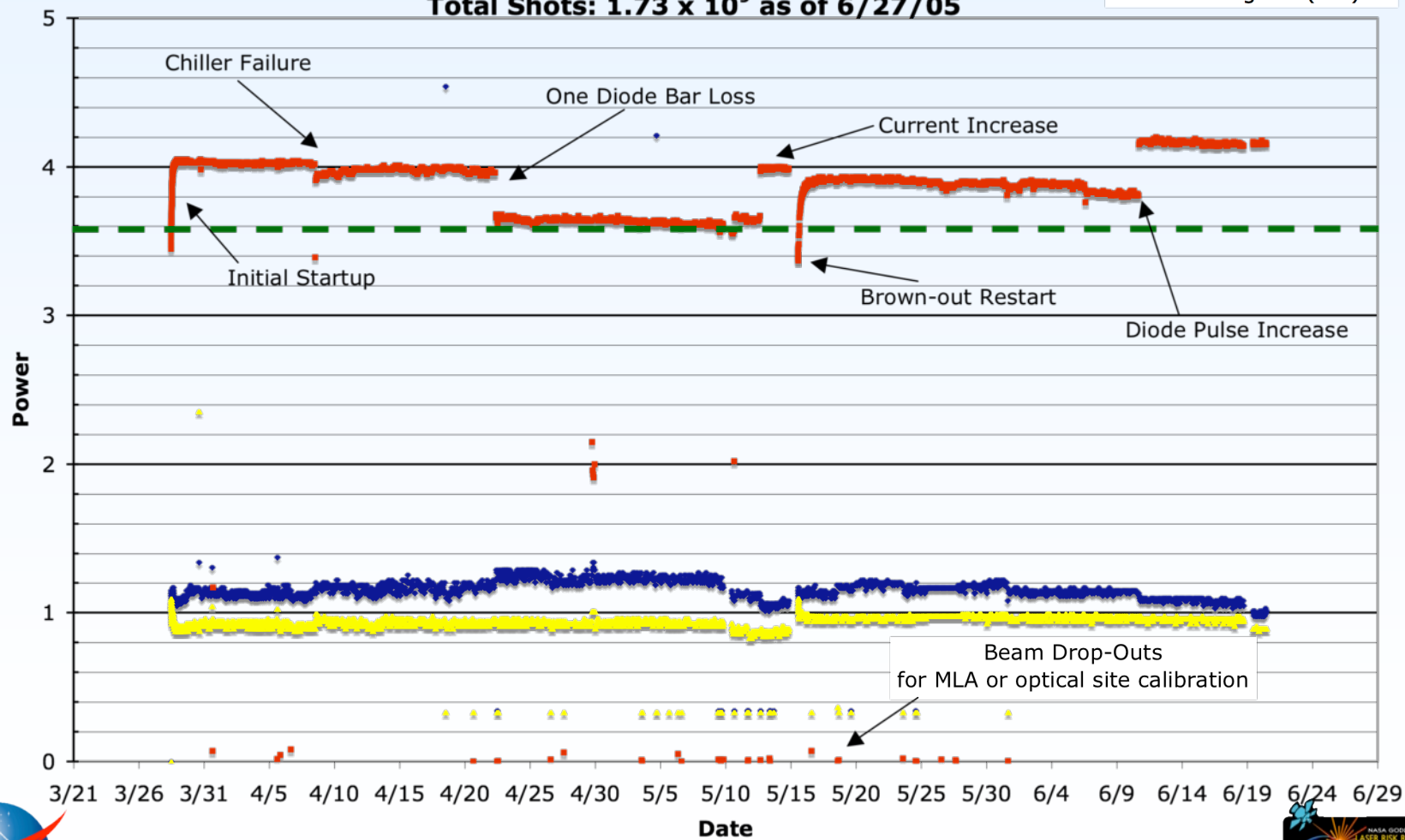
# HOMER Long Term Operation

Test Begun:  
3/28/05 @ 11:30 AM

**HOMER-1 Power/Energy Performance**  
**20.7 million shots per day**

**Total Shots:  $1.73 \times 10^9$  as of 6/27/05**

- X Divergence(mR)
- Power(W)
- Y Divergence(mR)



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# Future Plans

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- HOMER is main laser for ESSP BioMM Biomass Monitoring Mission. Proposal effort underway for August ESSP ARO.
- Make copies for long term testing for quantifying effects of:
  - power cycling
  - thermal sweeps
  - diode derating
  - damage limits
- Working with Mark Stephen of 554 to plan independent testing of diode arrays for the 5 billion shot 2 yr lifetime.
- Various trade studies with needed components: GRM mount design, pressurized vs evacuated enclosure.



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